PROJECT TITLE: Vulnerability Assessment for the Comprehensive Wetland Assessment and Monitoring Program for the Lostwood Complex

FY13

PROJECT DESCRIPTION

The Williston Basin is a leading source of domestic oil and gas production and water (brine) co-produced with oil in this area is some of the most saline in the nation. The Prairie Pothole Region (PPR), characterized by glacial sediments and numerous wetlands, covers much of the Williston Basin. The Lostwood Refuge Complex (LRC) manages several hundred Waterfowl Production Areas (WPAs) and National Wildlife Refuges within the PPR of the Williston Basin. Brine contamination to aquatic resources (surface and shallow groundwater) has been documented near oil-field sites in the Williston Basin and PPR[1]. However, the extent of brine contamination on LRC parcels is unknown.

The USFWS is partnering with the USGS Science Team about Energy in Prairie Pothole Environments (STEPPE) on a multiyear project to evaluate brine contamination in the LRC. STEPPE scientists conducted a GIS-based vulnerability assessment of brine contamination to aquatic resources in Sheridan County, Montana, which lies in the PPR of the Williston Basin[2]. The presence and magnitude of brine contamination in this area is determined by the Contamination Index (CI), the ratio of chloride concentration (mg/L) to specific conductance (μS/cm), of a water sample with values > 0.035 indicating contamination[3]. The Sheridan County assessment was successful at identifying areas with high and low levels of contamination based on CI values from water samples collected to evaluate the assessment. Building off of this work, the first step of the multiyear project was to conduct a similar vulnerability assessment for LRC parcels.

OBJECTIVES AND ALTERNATIVES

The primary goal of this project was to conduct a vulnerability assessment to evaluate brine contamination to aquatic resources on 194 parcels in the LRC. Prior to conducting the

analysis, the surficial geology of the six counties in the study area had to be reclassified from the Soil Survey Geographic (SSURGO) Database. Project results will guide the prioritization of water sampling efforts to assess the extent and magnitude of brine contamination in the LRC.

METHODS AND PROTOCOLS

Vulnerability assessments often use the index method, where relevant indices are identified and quantitatively combined with different numerical scores and weights based on the importance of physical attributes in influencing vulnerability, the natural variability, and the availability and spatial resolution of the data. Indices used in the LRC vulnerability assessment included the age and density of oil wells (data from the Montana Board of Oil and Gas and North Dakota Industrial Commission), percent of glacial outwash (determined from the SSURGO Database), percent of wetlands (determined from the National Wetland Inventory), and the length of stream reach (determined from the National Hydrography Dataset). To account for different WPA sizes, the values for all variables were normalized to the area of the quarter mile buffer. The spatial scale of the vulnerability assessment analysis included a quarter mile buffer around each of the LRC parcels to incorporate the oil field sites and hydrogeological settings in close proximity to LRC parcels.

The three models developed for this project included a standard deviation (SD) model, an equal interval (EI) model, and one using the structure from the Sheridan County (SC) model. The three models all used the variables described above; however, different scores and weights were applied to these variables depending on the model. The range of values in the dataset for each variable was calculated and the scores for each variable were determined by the standard deviation in the data for the SD model or by dividing the range of values into equal intervals

for the EI and SC models. All variables had equal weights in the SD and EI models and the variable scores were added together. In the SC model, the oil well density acted as a weighted multiplier.

Water samples were collected from a subset of the modeled WPAs during previous studies and were used to evaluate model outputs. For each model, the relative ranking of the sampled WPAs were plotted against both the maximum and average CI value obtained from these WPAs. Therefore, in a successful model, the WPA ranks would increase as CI values increased. Water samples used in the model validation all had CI values > 0.035 and included both surface water and groundwater samples collected by the UFWS in 2004-6 and by the USGS in 2011.

DATA ANALYSIS / MODELS

Comparison of the models to the maximum and average CI values from the subset of sampled WPAs determined the SC model performed the best. The SC model had better R^2 values than either the SD or EI models when comparing the relative ranks of the subset of sampled WPAs to USFWS and USGS surface water data and USGS groundwater data. The SD and EI models performed better than the SC model when evaluated against the USGS surface water data; however; this difference was minimal and much less than the differences between the SC model and the SD and EI models when evaluated against the other water quality datasets. In addition, only the SC model scored the 66 LRC parcels with oil wells within the quarter mile buffer and/or WPA higher than the 129 parcels without oil wells in the buffer and/or WPA. Therefore, this model was chosen to rank LRC parcels based on the potential of brine contamination and will be used to prioritize future water sampling efforts.

DATA MANAGEMENT

Spatial datasets were managed in a GIS with all spatial analyses, including reclassification of the

SSURGO database, performed in ArcGIS 10.1. Development and validation of the vulnerability assessment models were performed in Microsoft Excel. Data were provided to the USFWS in shapefile and Excel formats.

PARTNERS

Over 5 people have been involved in the project, representing 3 agencies/organizations and 1 Landscape Conservation Cooperatives.

SOURCES OF SUPPORT

CURRENT STATUS

This portion of the project is complete and the results have been provided to the LRC.

MORE INFORMATION

Contact Todd Preston (tmpreston@usgs.gov) or Mike Borgreen (mike_borgreen@fws.gov) for project information. Information on the USGS STEPPE program is available on our website.

www.steppe.cr.usgs.gov

LITERATURE CITATION

[1]Murphy, E.C., Kehew, A.E., Groenewold, G.E., and Beal, W.A., 1988, Leachate generated by an oil-and-gas brine pond site in North Dakota: Ground Water, v. 26, p. 31-38.

[2]Preston, T.M., Chesley-Preston, T.L., and Thamke, J.N., In Press A GIS-based vulnerability assessment of brine contamination to aquatic resources from oil and gas development in eastern Sheridan County, Montana: Science of the Total Environment

[3]Reiten, J., and Tischmak, T., 1993, Appraisal of oil-field brine contamination in shallow ground water and surface water, eastern Sheridan County, Montana: Montana Bureau of Mines and Geology open file report 260, 296 p.